

FURTHER STUDIES ON THE SEX RATIO IN THE CHICKEN.¹

W. V. LAMBERT AND V. CURTIS.

In the chicken, as in other animals, various attempts have been made to influence the proportion of the sexes normally obtained. While many claims have been made to the effect that it is possible to control sex, at least to a certain degree, most of these claims have not been substantiated when put to a careful analysis. Since such claims have been and will, no doubt, continue to be made it is desirable to have at hand a large body of data on the normal sex ratio for the fowl collected in different localities and over a considerable period of time.

It was in the hope that the observations here reported will add materially to this question, as well as to the question of the normal embryonic sex ratio in the fowl, that the present data were collected. Since the observations were made incidental to another problem, it is deemed wise to publish them at this time.

As these data were collected over a period of fourteen weeks and upon the chicks from hens of different ages they offer information as to the normal variability that may be expected in the sex ratio from week to week, and, also, from females of various ages. In addition, some data relative to the influence of previous and concurrent egg production on the sex ratio were accumulated.

MATERIAL AND METHODS.

The data reported herein were obtained primarily on the chicks from White Leghorn or White Leghorn by Rhode Island Red matings. In addition a few chicks were from pure Rhode Island Red stock. As a part of the chicks were obtained from sources other than pedigreed matings no attempt was made to keep the sex ratio for the two breeds and the hybrids separately.

All eggs were candled on the fourteenth and eighteenth days of

¹ Paper No. 30—Department of Genetics, Iowa State College, Ames, Iowa.

incubation and the sex of all embryos dead after the fourteenth day of incubation was determined by dissection. Likewise, the sex of all chicks dead before their sex could be ascertained from external examination, was made in a similar manner.

The sex ratio, as used in this report, expresses the percentage of males to females in the population.

THE NORMAL SEX RATIO IN THE CHICKEN.

Most of the investigators who have reported upon the sex ratio of the chicken have observed a slight excess of females. The results of all the separate investigators with a total of all the results are shown in Table I. A total of 38,907 observations have been

TABLE I.

A SUMMARY OF THE RESULTS OF ALL INVESTIGATORS OF THE SEX RATIO IN THE CHICKEN.

Author.	Year.	Total No. of Observations.	Ratio of ♂♂.
Darwin.....	1871	1,001	48.65 ± 1.06
Field.....	1901	2,103	44.63 ± 0.73
Thomson.....	1911	805	47.82 ± 1.19
Pearl ¹	1917	22,791	49.45 ± 0.22
Crew and Huxley.....	1923	753	49.26 ± 1.23
Jull.....	1924	2,396	48.88 ± 1.69
Mussehl.....	1924	1,514	52.24 ± 0.87
Lambert and Knox.....	1926	2,910	51.13 ± 0.62
Horn.....	1927	2,131	51.62 ± 0.73
Lambert and Curtis.....	(This report)	2,501	46.82 ± 0.67
Totals.....		38,907	48.76 ± 0.17

¹ All sized families.

made, upon chicks and embryos, and the sex ratio for this total group is 48.76 ± 0.17 . The lowest sex ratio, 44.63, was reported by Field (1901) and the highest, 52.25, by Mussehl (1924). The largest series of observations, 22,791, on the sex ratio in the chicken has been made by Pearl (1917). These observations were made over a period of eight years (1908-1915), and the range in the percentage of males reported by Pearl for the different years is from 46.16 to 49.99. Two other ratios above fifty have been reported, 51.13 (Lambert and Knox, 1926) and 51.62 (Horn, 1927).

The observations reported herein were made over a period of fourteen weeks, from April 11 to July 17, 1928. During this period a total of 2,501 chicks and embryos were examined for their sex. The total results listed by weeks for both chicks and dead embryos are given in Table 2. Of the 2,501 chicks and embryos examined 1,171 were males and 1,330 were females, or a sex ratio of 46.82 ± 0.67 . Considerable variation was exhibited in the sex ratio for the various weeks, this ranging from 38.67 for the week of June 27 to 55.75 for the week of July 5. These are rather extreme deviations for the normal sex ratio, but as they are based upon rather small populations they are probably due entirely to chance. It is noteworthy, however, that in only three out of the fourteen weeks were sex ratios as high as fifty observed.

TABLE II.

THE SEX RATIO LISTED BY WEEKS THROUGHOUT THE HATCHING SEASON FOR ALL CHICKS AND EMBRYOS EXAMINED.

Date of Hatch.	Dead Embryos.		R. ♂♂.	Chicks.		Total.		R. ♂♂ Total.
	♂♂.	♀♀.		♂♂.	♀♀.	♂♂.	♀♀.	
April 11.	34	38	47.22	57	63	91	101	47.39 \pm 2.43
" 18.	67	68	49.62	3	2	70	70	50.00 \pm 2.85
" 25.	55	64	46.21	13	17	68	81	45.63 \pm 2.76
May 2.	12	20	37.50	57	67	69	87	44.23 \pm 2.70
" 9.	37	43	46.25	46	42	83	85	49.40 \pm 2.60
" 16.	21	27	43.75	77	79	98	106	48.03 \pm 2.36
" 23.	13	13	50.00	115	133	128	146	46.71 \pm 2.04
" 30.	10	5	66.67	66	85	76	90	45.78 \pm 2.62
June 6.	15	14	51.72	47	78	62	92	40.25 \pm 2.72
" 13.	15	23	39.47	72	81	87	104	45.54 \pm 2.44
" 20.	13	4	76.47	102	104	115	108	51.56 \pm 2.26
" 27.	11	13	45.83	30	52	41	65	38.67 \pm 3.27
July 5.	6	5	54.54	62	49	68	54	55.73 \pm 3.05
" 17.	15	23	39.47	100	118	115	141	44.92 \pm 2.11
Totals.	324	360	47.36 \pm 1.29	847	970	1,171	1,330	46.82 \pm 0.67

No definite trend in the sex ratio is apparent as the season advanced, as both the lowest and the highest ratios appear in the last three weeks of the hatching season.

During the hatching season a total of 3,907 eggs were set and of this total 2,965 proved to be fertile. Of the fertile eggs, as determined by candling on the fourteenth day of incubation, 424

were embryos dead before the fourteenth day. A total of 684 embryos died between the fourteenth and twenty-first days of incubation, while 1817 of the eggs hatched. Forty of the chicks were lost before their sex was determined. These data, therefore, represent 84.35 per cent. of all the fertile eggs that were set. This figure is probably slightly high as some of the eggs classed as infertile must have been dead germs, although the percentage of such eggs cannot have been large.

Most of the chicks and embryos examined for their sex were from pedigreed matings, and the results for each colony of matings are listed in Table 3. Only one male was used in each of the

TABLE III.

THE SEX RATIO LISTED BY COLONIES. ONE MALE WAS USED IN EACH COLONY.¹

Colony No.	No. of Females.	Dead Embryos.		Chicks.		Total.		R. ♂♂.
		♂♂.	♀♀.	♂♂.	♀♀.	♂♂.	♀♀.	
1.....	23	62	58	90	75	152	133	53.33 ± 2.00
2.....	10	25	28	71	80	96	108	47.95 ± 2.36
3.....	12	4	7	41	43	45	50	47.37 ± 3.46
4.....	8	25	28	66	62	91	90	50.27 ± 2.51
5.....	7	3	3	19	18	22	21	51.16 ± 5.14
6.....	12	37	38	79	85	116	123	48.53 ± 2.14
7.....	11	24	40	90	113	114	153	42.70 ± 2.06
8.....	12	39	40	86	87	125	127	49.60 ± 2.12
9.....	11	17	17	56	71	73	88	45.34 ± 2.66
10.....	11	22	27	50	43	72	70	50.70 ± 2.83
11.....	10	10	9	14	21	24	30	44.44 ± 4.59
Totals ...		268	295	662	698	930	993	48.36 ± 0.77

colonies. From this series of matings a total of 1,923 chicks and embryos was examined. Of this number 930 were males and 993 were females, the sex ratio being 48.36 ± 0.77 . The range noted in the sex ratio of the different matings was from 42.70 to 53.33. While these are rather wide deviations from the average they are undoubtedly due to chance. When the sex ratio for each

¹Some females were transferred from one colony to another during the course of the hatching season, after being away from the male of the first colony for a period of at least ten days. Altogether 79 females were used in this series of matings.

separate mating is considered it is found that most of the deviation in colony 1 is due to the aberrant ratio of two females and in colony 7 to the high percentage of females produced by three hens. In neither colony is the deviation great enough for any one hen, when both embryos and chicks are considered, to lead to the suspicion of factors other than chance having been responsible for the ratio in question.

The females used in this study were of different ages and the sex ratio from different aged females has been listed in Table 4. Five females were in their third or fourth year of production, 11 in their second year and 63 in their first year. The sex ratios for these three groups were 50.38, 44.03 and 48.79 respectively. While the number of birds in the first two groups is obviously too small to make sweeping conclusions it is apparent that age does not seem to modify the sex ratio greatly. The ratio of males is rather low for the two-year-old hens, but if reference is made to Tables 1, 2 and 3 it will be seen that deviations equally as great are not infrequent in populations as large or larger.

TABLE IV.
THE SEX RATIO CONSIDERED BY AGE OF DAM.

Year of Production.	No. of Females.	Dead Embryos.		Chicks.		Total.		R. ♂♂.
		♂♂.	♀♀.	♂♂.	♀♀.	♂♂.	♀♀.	
4	5 ¹	18	21	48	44	66	65	50.38 ± 2.62
2	11	21	30	75	92	96	122	44.03 ± 2.28
1	63	229	244	539	562	768	806	48.79 ± 0.85
		268	295	662	698	930	993	48.36 ± 0.77

THE EMBRYONIC SEX RATIO IN THE CHICKEN.

In some species of animals, notably man, a considerable body of evidence has been presented to show that the primary sex ratio differs rather markedly from the secondary ratio. In fowls this does not seem to be the case. While the data on this question are not as extensive as might be desired they all point to the above conclusion. Pearl (1917) reports a sex ratio of 48.30 from a

¹ Four of the females were in their fourth year of production, one in the third.

total of 1,921 embryos examined from the tenth to twenty-first days of incubation. Jull (1924) a ratio of 42.10 in embryos dying naturally after the eleventh day of incubation, Thomson (1911) a ratio of 47.82 in 805 embryos, and Crew and Huxley a ratio of 45.24 in a total of 420 observations. Lambert and Knox (1926) observed a sex ratio of 51.43 in 1,048 embryos dead after the twelfth day of incubation, and Horn (1927) a ratio of 52.17 in 1,248 embryos examined from the tenth to the twenty-first days of incubation. This is a total sex ratio for dead embryos examined by all investigators heretofore of 48.80 ± 0.44 .

In this study a total of 684 embryos dead before hatching were sexed. Of this group 324 were males and 360 females, giving a sex ratio of 47.36 ± 1.29 . This result agrees well with the findings of other investigators, and when compared with the sex ratio of chicks it does not offer any evidence for a selective prenatal mortality of one sex in the chicken, at least during the latter part of the incubation period.

All of the observations on the embryonic sex ratio have been made only during the latter half, or less, of the incubation period. To change the sex ratio to an equality of males and females, it would be necessary to assume a very heavy mortality of males during the first half of the incubation period, and there is no good reason for believing that the early embryonic death ratio would be greatly different from that observed in the late stages of hatching.

ANTECEDENT PRODUCTION AND THE SEX RATIO.

Jull (1924) in a study of the sex ratio based upon continuous hatches throughout the year found a correlation of $-.704 \pm 0.031$ between the sex ratio and antecedent egg production. The ratio of males was found to decrease as the season advanced and total egg production increased, and Jull concluded that the cause for this decrease was directly related to antecedent egg production. Such a decrease was not noted by Jull during the normal hatching season.

Lambert and Knox (1926) did not find any significant correlation with the sex ratio, either for rate of production preceding the normal hatching season, or the actual production during the

normal hatching season. The respective correlations reported by them were $-.048 \pm 0.111$ and $-.009 \pm 0.108$.

Similar studies have been made for the data here reported. Correlations were calculated between the sex ratio and the rate of production for the three months preceding the hatching season, and for the actual production from March 1 to June 1. Only hens producing at least ten sexed offspring have been used in these calculations. The results with the sex ratio as the dependent variables are as follows:

Variables.	Correlation Coefficient.
A. Rate of production preceding the hatching season (per cent.)	$-.05 \pm 0.19$
B. Actual production (March 1 to June 1) ..	$.09 \pm 0.13$

The size of neither of the correlation coefficients is great enough to indicate that there was a relationship between production and the sex ratio. While the number of hens upon which these observations were made was not large it is certain that the immediate antecedent production or concurrent production did not exert any noticeable influence upon the sex ratio of the chicks from these hens. These findings are in accord with those of previous investigators.

SUMMARY.

1. The sex ratio for a total of 2,501 chicks and dead embryos examined from April 11 to July 17, 1928, was 46.82 ± 0.67 . This represents the sex ratio upon 84.35 per cent. of all fertile eggs set during this period.

2. The sex ratio observed for dead embryos alone was 47.36 ± 1.29 and for chicks alone it was 46.61 ± 0.79 .

3. Evidence is presented to show that there is not a selective mortality against one sex previous to the time of hatching.

4. No definite tendency of the sex ratio to increase or decrease was observed during the hatching season.

5. Separate tabulations for the sex ratio upon eleven colony matings, one male with several females in a colony, did not show significant differences between the colonies that might be traceable to individual differences.

6. No significant differences for the sex ratio of hens of different ages were noted.

7. Egg production for the three months immediately preceding the hatching season, or egg production during the hatching season did not influence the sex ratio. The respective correlation coefficients were $-.05 \pm 0.19$ and $.09 \pm 0.13$.

LITERATURE CITED.

Crew, F. A. E., and Huxley, J. S.

- '23 The Relation of Internal Secretion to Reproduction and Growth in the Domestic Fowl. I. Effect of Thyroid Feeding on Growth Rate, Feathering, and Egg Production. *Vet. Jour.*, 79: 343-348.

Darwin, Charles.

- '71 *The Descent of Man*. Vol. 1, p. 296. D. Appleton and Co., New York.

Field, G. W.

- '01 Experiments on Modifying the Normal Proportion of the Sexes in the Domestic Fowl. *BIOL. BULL.*, 2: 360-361.

Horn, E.

- '27 Untersuchungen über die Möglichkeit einer Geschlechtsvorausbestimmung beim Hühnerei nebst einer Factorenanalyse der Befiederungsgeschwindigkeit von Kücken. *Zeitschr. Tierzucht. u. Zuchtungsbiol.* 10: 179-224.

Jull, M. A.

- '24 The Relation of Antecedent Egg Production to the Sex Ratio of the Domestic Fowl. *Jour. Agr. Res.*, 28: 199-224.

Lambert, W. V., and Knox, C. W.

- '26 Genetic Studies in Poultry. I. The Sex Ratio in the Domestic Fowl. *BIOL. BULL.*, 51: 225-236.

Mussehl, F. E.

- '24 Sex Ratios in Poultry. *Poult. Sci.*, 3: 72-73.

Pearl, R.

- '17 The Sex Ratio in the Domestic Fowl. *Proc. Amer. Phil. Soc.*, 56: 416-436.

Thomsen, E.

- '11 Die Differenzierung des Geschlechts und das Verhältnis der Geschlechter beim Hünchen. *Arch. Entwick. Organismen*, 31: 512-530.